



# Lichen Communities in Colorado’s Park Range and the Influence of Two Coal Fired Power Plants

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## INTRODUCTION

Lichen communities are included in the Forest Health Monitoring program because they directly address several key resource assessment questions on the contamination of natural resources, biodiversity, forest health, and sustainability of timber production. Hundreds of papers worldwide and dozens of review articles and books have documented the close relationship between lichen communities and air pollution, especially SO<sub>2</sub> and acidifying or fertilizing nitrogen and sulfur-based pollutants. Quantitative relationships between lichen communities and air pollutants can be established when sufficient air quality data are available through lichen chemistry or direct air monitoring (McCune 1988; de Wit 1976).

Steamboat Springs and the Park Range are downwind of two large coal-fired utilities. Combined, the power plants annually emit an estimated 20,000 metric tons of sulfur dioxide and 25,000 tons of nitrogen oxides. Lichen tissue analysis in the nearby Mount Zirkel Wilderness indicates that sulfur concentrations are the highest in western Colorado, and sulfur isotope studies reveal the fingerprint of local power plant emissions in lichen tissues (Jackson et al. 1996).

Previous Forest Health Monitoring off-frame sampling in the Steamboat Springs and Hayden areas suggested that lichen communities have already been altered. Lichen diversity on the lower to mid slopes in these areas was considerably lower than in analogous clean air sites (n=6), but more sampling was needed to document the severity and extent of the problem (McCune et al. 1998). While chemical analysis of lichens at higher zones showed greatly elevated sulfur levels, sampling intensity has not been sufficient to establish impacts to communities. Impacts are suspected at higher elevations, however, because of low pH and high sulfates in the snowpack, and considerable impacts to aquatic ecosystems (T. Blett, pers. comm.). The USDA/Forest Service recently issued a certification of impairment of a Class I airshed attributable to the power plants. As a result, strict emissions control technologies were mandated and are beginning to be incorporated.

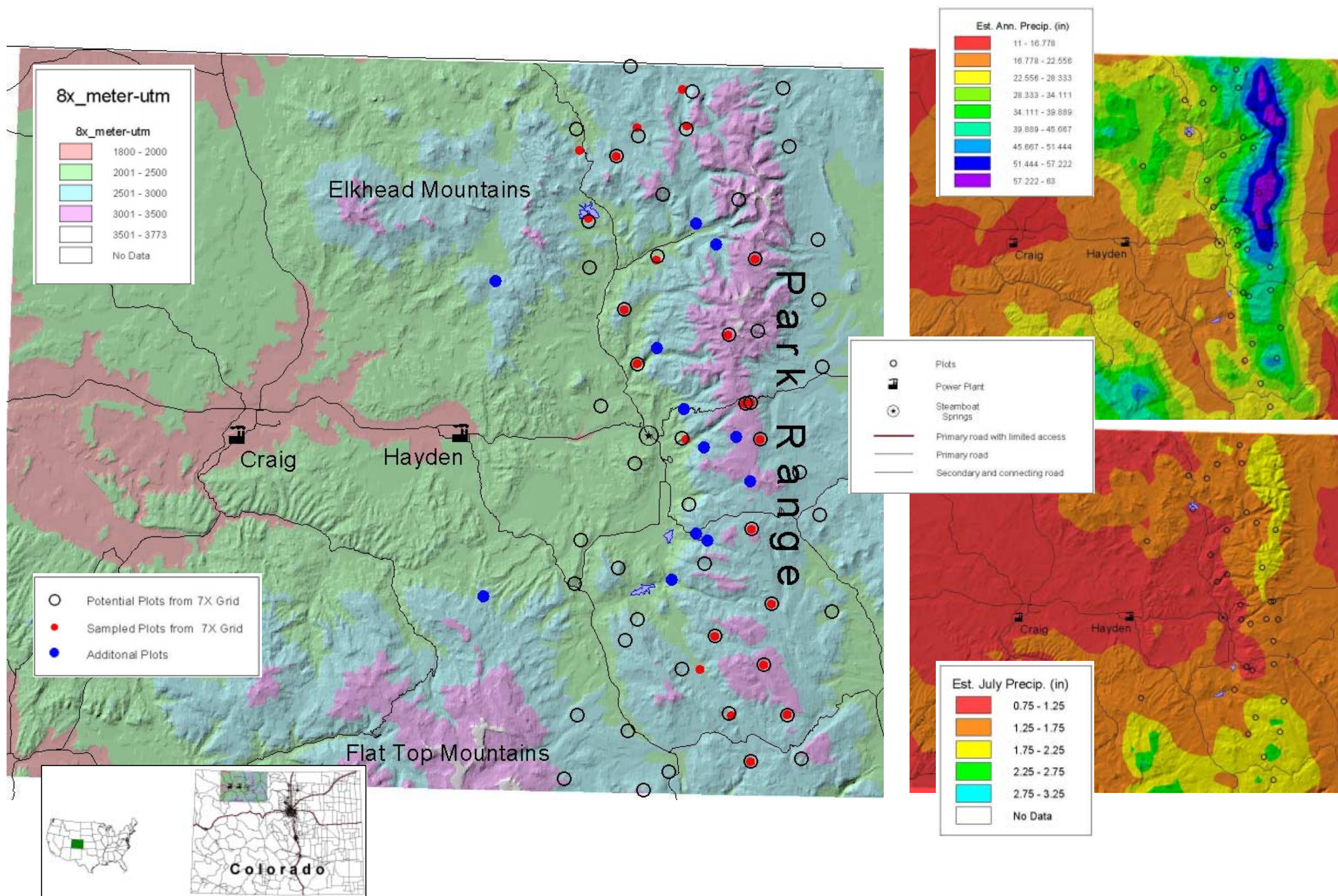
Our intensified sampling allows us to: (1) document the nature and degree of the impacts to the resources from 30 years of emissions and (2) establish a baseline with which to document long term changes associated with anticipated air quality improvement from cleaner emissions.

## METHODS

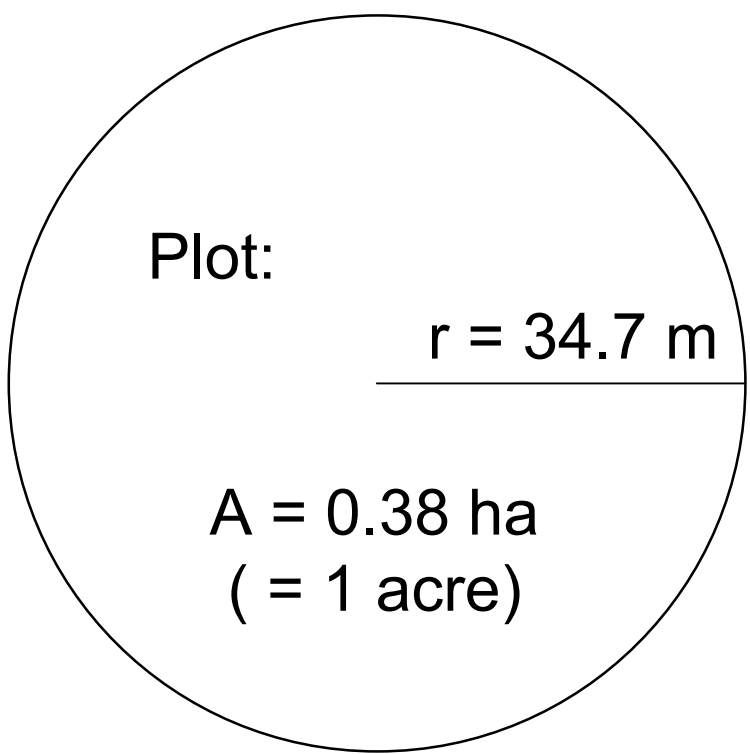
1. A 7x intensified sampling grid was obtained for a 1-degree block that focused on the western slopes of the Park Range. This intensification resulted in 51 potential plot locations. Of these, 23 were located in the area of interest and were reasonably accessible. An additional 10 plots were placed in locations chosen on small scale maps to fill in geographical or environmental gaps. Two plots were placed to add to previous samples in the Flat Top and Elkhead Mountains. Algorithms for precise placement of the additional plots were chosen prior to arrival so as to reduce potential for bias. (See Inset 1)
2. Sampling involved standard off-frame lichen community plots (Inset 2).
3. Selected site and stand variables that are likely to be important to the lichen communities were recorded. These include: elevation, slope, aspect, basal area and age for both hardwoods and conifers, variation in total basal area, and canopy density. Estimated annual precipitation (dominated by winter snow) and July precipitation (dominated by afternoon rain showers) was obtained for each plot from PRISM models (Daly et al. 1994).
4. Data is being analyzed by ordination and according to the methods proposed by McCune et al. 1997 and McCune et al. 1998, which includes a method for scoring air quality according to lichen communities in Colorado.

Field work was conducted during the summer of 2000 by the first author. Specimens were identified during Fall of 2000, though some are still being verified by experts. A preliminary report will be ready by April, 2001. A final report will be issued by September, 2001.

### Inset 1: Sampling Design



### Inset 2: Plot Design



Standard off-frame lichen community plots are large, circular plots with time constrained sampling (max. 2 hours). The large area trades precision information on lichen cover for higher species capture, resulting in a better measure of species diversity. A combination of GPS coordinates, detailed location notes, and permanent markers will allow plots to be precisely relocated for future monitoring.

RESULTS

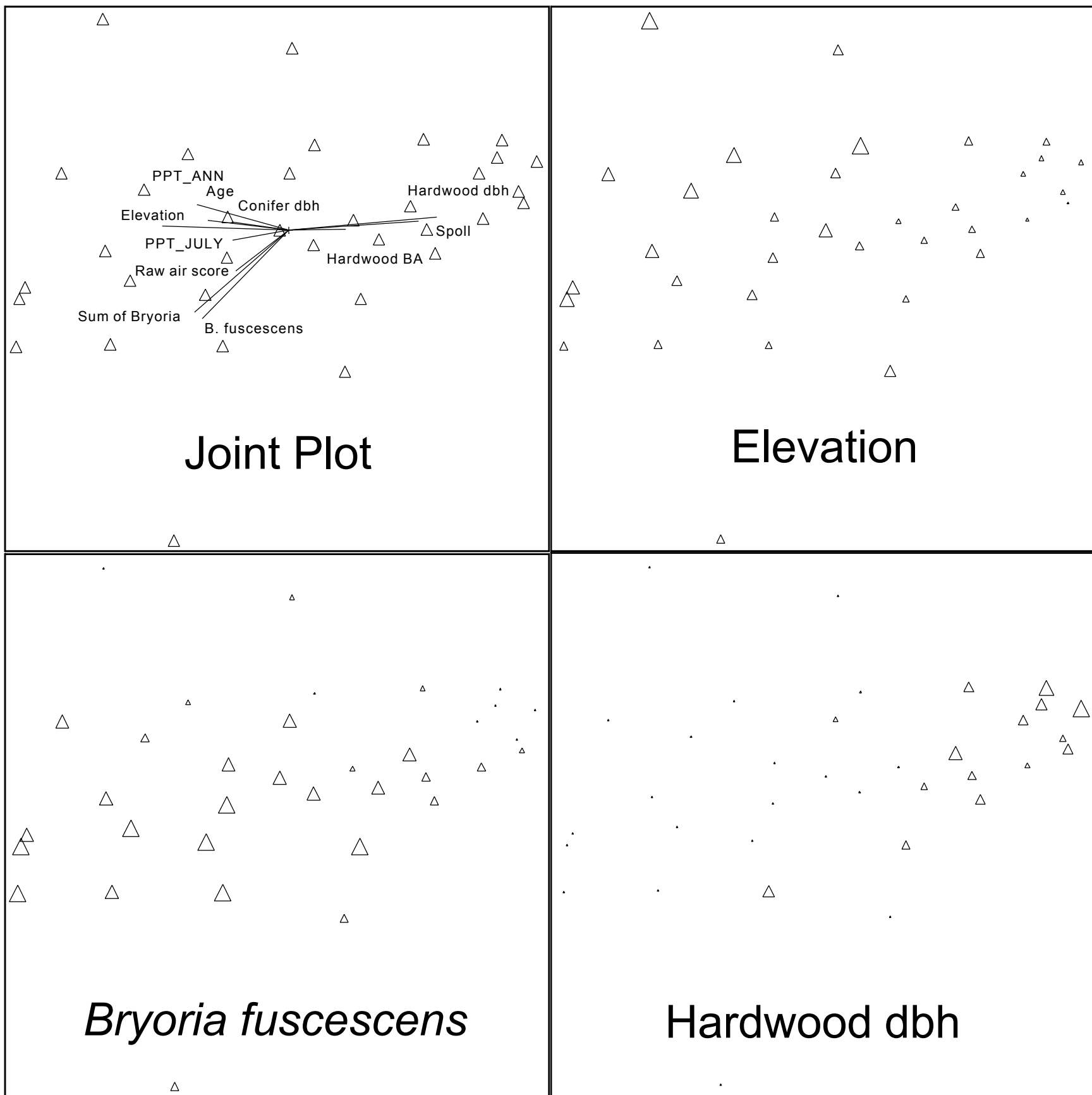
Results are preliminary, because some specimens are still being examined by experts. Among the 35 plots, we found 43 species (Inset 3)

Inset 3: Species List

Species	# plots	Species	# plots
<i>Bryoria fremontii</i>	8	<b><i>Physcia biziana</i></b>	<b>1</b>
<i>Bryoria fuscescens</i>	28	<i>Physcia adscendens</i>	27
<i>Bryoria lanestris</i>	6	<b><i>Physcia aipolia</i></b>	<b>2</b>
<i>Bryoria simplicior</i> (?)	2	<i>Physcia dimidiata</i>	1
<b><i>Candelaria concolor</i></b>	<b>31</b>	<i>Physcia dubia</i>	2
<i>Cladonia coniocraea</i> (gr.)	3	<i>Physcia stellaris</i>	13
<i>Cladonia fimbriata</i>	2	<i>Physcia tenella</i>	25
<i>Cladonia chlorophaea</i> (gr.)	1	<i>Physconia enteroxantha</i>	2
<i>Evernia divaricata</i>	5	<i>Physconia "stellaroid"</i>	4
<i>Hypogymnia austerodes</i>	2	<i>Ramalina obtusata</i>	1
<i>Melanelia subolivacea</i>	16	<i>Ramalina sinensis</i>	2
<b><i>Melanelia elegantula</i></b>	<b>25</b>	<i>Rhizoplaca chrysoleuca</i>	2
<i>Melanelia exasperatula</i>	34	<i>Usnea cavernosa</i>	5
<i>Melanelia subelegantula</i>	2	<i>Usnea hirta</i>	1
<i>Nodobryoria oregana</i>	1	<i>Usnea lapponica</i>	19
<i>Parmeliopsis ambigua</i>	8	<i>Usnea substerilis</i>	34
<i>Parmeliopsis hyperopta</i>	1	<i>Vulpicida pinastri</i>	2
<i>Phaeophyscia cernohorskyi</i>	2	<b><i>Xanthoria fallax</i></b>	<b>13</b>
<b><i>Phaeophyscia hirsuta</i></b>	<b>3</b>	<b><i>Xanthoria fulva</i></b>	<b>16</b>
<b><i>Phaeophyscia nigricans</i></b>	<b>7</b>	<i>Xanthoria montana</i>	23
<i>Phaeophyscia "nigricoid"</i>	1	<i>Xanthoria polycarpa</i>	1
<b><i>Phaeophyscia orbicularis</i></b>	<b>5</b>		

Inset 4: Gradients

NMS Ordination revealed gradients that correlate with species composition. All gradients that correlated with  $r^2 \geq 0.200$  are included in the Joint Plot; strength of the correlation is represented by the length of the vector. For other graphs, symbol size corresponds to the value of the variable shown.



Inset 5: Air Pollution

McCune et al. 1998 developed an equation to score air quality at a plot in Colorado according to the relative proportion of pollution associated species (bolded in the species list) and an adjustment for non-pollution gradients that influence the presence of those species:

Raw air score

Adjusted air score

$$= 100 \left( 1 - \frac{S_{poll}}{S} \right)$$

where  $S_{poll}$  is the sum of abundance classes of the pollution associated species,  $S$  is the sum of the abundance classes of all species in the plot,  $f(\text{environment})$  is the function obtained by regressing the raw air scores against non-pollution environmental variables, and  $SD$  (residuals from  $f(\text{environment})$ ) is the standard deviation of residuals from the regression.

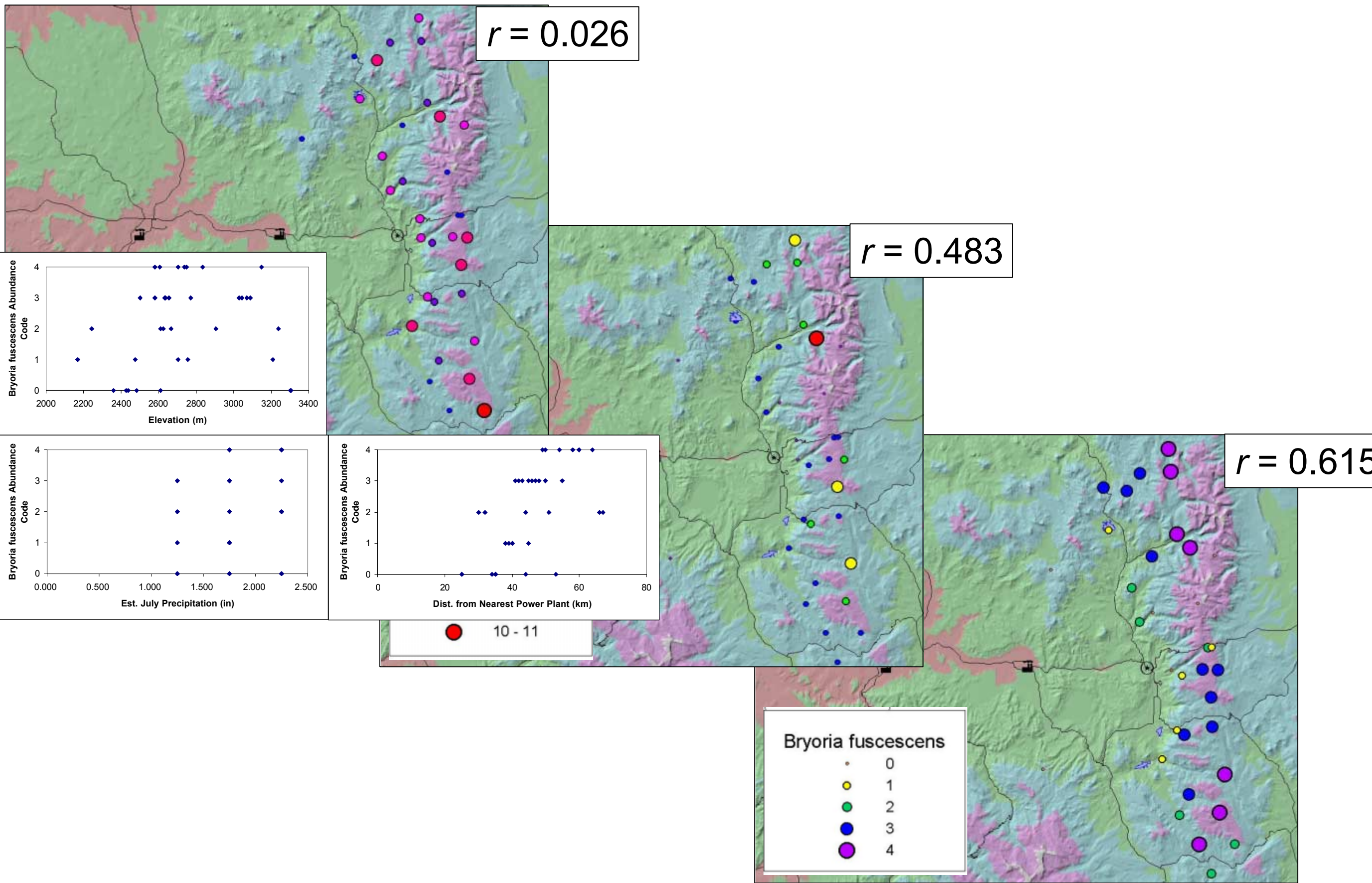
Regression revealed that our raw air scores were a function of elevation and the presence of *Populus tremuloides*.

Term	Coefficient	p-value
Constant	-374.63	0.000878
Elevation	0.331	0.0000695
Elevation <sup>2</sup>	-0.00005973	0.0000542
P. tremuloides	-9.822	0.0062

However, the variation remaining in our adjusted air scores did not correlate with the distance from the nearest power plant.

What did correlate with distance from the nearest power plant (DIST) was the pollution intolerant genus *Bryoria*, particularly the most abundant species, *Bryoria fuscescens*. For our localized data, it appears that the lack of pollution intolerant species is more important than the presence of pollution tolerant species.

The story is still somewhat complicated, as DIST is correlated with July (liquid) precipitation at our plots ( $r = 0.656$ ). However, *Bryoria fuscescens* is not directly correlated with July (liquid) precipitation ( $r = 0.265$ ). Regression describes the abundance of *B. fuscescens* as a function of DIST (p-value = 0.00009) but not July precipitation (p-value = 0.124).



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